This subject is so little (generally) understood, that it seems necessary to use the above illustration for the benefit of the casual reader, although to the chemist a hundred different applications of the same law will suggest themselves. Indeed, it is noted here for the purpose of calling more emphatic attention to the simple fact that water may contain impurities in absolute (chemical) solution, and that such impurities, by the addition of another substance, may be rendered tangible, and capable of withdrawal from the water by purely mechanical means.

Equally clear and understood should be the statement that water may contain impurities in a state of fine (mechanical) suspension, — so fine that they would flow wherever water would flow, — and these, by the addition of another substance to the water, be made to flock together into groups, a thousand or two into one (as clouds are condensed into drops); and that one, with its fellows, be tangible, and easily removed from the water by purely mechanical means.

It follows, that if the earth contains in abundance this "substance," which has the dual property of disengaging matter held in solution, and rendering the same tangible, and also of curdling together matter held in so fine a state of division as to almost elude the senses into a state of perfect tangibility, we at once get at the secret of how nature makes the true spring-water, so wonderfully pure and sweet to the taste, as well as brilliantly clear, and inviting to the eye.

What is this substance or substances? Usually some combination of lime, iron, potassium, aluminum, etc., with other bases, such as sulphur or carbon, — all existing naturally in the great mother matrix, the earth.

The almost universal diffusion of the aluminiferous earth (red clay) makes that substance take a more prominent place among the agents above alluded to. Water cannot flow far in any part of the world without encountering in its course the coagulating or curdling effect of this single element. Some of these clays are more heavily charged or freighted with aluminous compounds than others. Waters fouled by such are more quickly subsided. In this fact we have a clew to the explanation of why it is, that, of two different waters showing the same degree of turbidity from clayey impurities, such impurities will subside quickly in one, while in the other they may not subside in months. As proof that the quick subsidence is due to the presence of these salts, we have only to add a minute proportion of such (usually aluminum sulphate) to the other water to produce the same effect. Hence, when water issues from the earth in a very clear and perfect state, we may always be sure that it has encountered somewhere on its travels a body of earth or mineral containing a suitable coagulant, the action of which coagulant upon the water accounts for its wonderful purity aside from and entirely independent of the mere filtering effect of the earth.

It has remained for the present decade to apply the above knowledge to the art of filtration of water, and for the first time produce results equal to nature.

As this industry extends, it will become a common thing to see "spring" water issue from our city faucets, as is already the case in a few American cities, notably Atlanta, Long Branch, and Newport.

The study of this subject furnishes a striking example of Nature's exhibiting, in the humble wayside "spring," the results of her perfect handiwork for the observation and admiration of man throughout all ages and countries, only to deliver up her secret to the pale student of this century of science.

JOHN A. CALDWELL.

THE USE OF SPIRIT AS AN AGENT IN PRIME MOVERS.

A PAPER on the above subject was prepared by A. F. Yarrow at the request of the Council of the London Society of Arts, and was presented May 22. It did not treat of the adoption of spirit or liquid hydrocarbons, such as petroleum, when used as a substitute for coal as fuel, which is an entirely distinct subject, but with the use of volatile liquids in lieu of water, to produce power, when converted by heat from the liquid to the vapor state, in the same way that power is obtained from the conversion of water into steam.

In the year 1856 this subject attracted much attention in France; and, as a matter of fact, several large steamers were built, and ran between Marseilles and Algiers, in which ether was evaporated in combination with steam for working the propelling machinery. The engines were on the Du Tremblay system. The steam, after having performed work in one cylinder, instead of going at once to the condenser, was used to evaporate ether in a tubular evaporator, by which means a portion of the remaining heat in the steam was absorbed instead of being wasted. The ether vapor so produced was used in another cylinder, the additional power thus obtained being a clear gain. These steamers ran, making regular voyages, for some years, but were ultimately abandoned.

The gain obtained is clearly due to the ether taking a portion of the heat of the exhaust steam, and turning it to useful account, which would otherwise be wasted in raising the temperature of the condensing-water. The ether used evaporates at about 104° F.: it will therefore be seen to what a low temperature the steam or water can be brought down, and still be useful in evaporating the ether.

The system was no doubt enconomical as regards fuel; but the ether was so difficult to keep, that a renewal of about one gallon per hour was required to make good the leakages. There was also serious risk of explosion on account of these leakages, because the ether, when free, rapidly vaporizes, and when in this state is explosive if mixed with the atmosphere. The difficulties which at that time had to be dealt with are, however, now greatly reduced. Ether, being the spirit used, was far more costly than other volatile liquids which are available now, and consequently any leakage then represented an important item in the working expenses; also, at that period, means for obtaining good workmanship were not available to the engineer, as they are at present, accuracy of workmanship, and soundness of materials, being essential points in dealing with the vapor of these volatile liquids, as it penetrates joints and castings which no steam would. In fact, an amount of care is necessary beyond what is needed in the best steam-engine practice, and sufficiently good work was not available thirty-two years ago.

The success of some small boats lately built in the United States, propelled by spirit vapor, induced Mr. Yarrow to take the matter up with a view to investigate it, and see whether the results would justify his going fully into the matter with a view to its further development. These preliminary investigations look promising.

The apparatus with which the experiments were tried was a small steam-engine of ordinary construction, which actuates a shaft and fly-wheel in the usual way. There was a brake attached to the shaft, with a spring balance and index; also a revolution counter, so that he was enabled to obtain the actual power developed. There was also fitted to this little engine an ordinary indicator, from which to obtain diagrams.

The steam-boiler had no special feature about it: it had simply a combustion-chamber and a straight flue through to the funnel. There was no attempt at economy of fuel, because there was no object in so designing it, all he wished to obtain being the comparative results on a common basis. The heat was obtained by means of ordinary gas, burnt in a large Bunsen burner. Gas was selected as the means of heating because the exact quantity could be accurately regulated and recorded, and with this view there was attached to the inlet pipe a gas-meter. The exhaust from the cylinder passed out, and terminated in a coil of pipe immersed in a tank of running water for the purpose of condensing the steam. From there the condensed steam ran into a hot-well, and passed on to the feed-pump on the engine, and was forced back into the boiler, so that an entire circuit was made. This completes the arrangement for working the engine by steam.

For the corresponding system, when spirit vapor was used, inside the upper part of the boiler was a copper coil, the inlet to which was at the side, and the outlet at the top, whence it passed to the engine. The exhaust pipe from the cylinder was led in this case into a tank where the vapor was condensed, and passed on to the hot-well, thence to the pump, and was forced back into the coil inside the boiler, thus making this circuit complete. Two sets of pipes, condensing-coils, etc., were adopted, so as to avoid, as far as

practicable, any mixture of water and spirit, which would tend to vitiate the experiments.

The heat from the gas-flame is first taken up by the water in the boiler, and is then passed on to the copper coil, and evaporates the spirit; the water only acting as a convenient means of transmitting the heat from the flame to the spirit. By these means it was possible to try steam and spirit vapor under precisely similar circumstances with regard to boiler efficiency.

The experiments consisted of several continuous trials, each of three hours duration, alternately with steam and with spirit vapor. The upshot of these experiments was, that although the amount of gas consumed during the three hours was practically the same, being at the rate of 82 and 83 cubic feet, the power obtained, as tested on the brakes, was, in the case of spirit, nearly twice that recorded in the case of water, the powers being as 4,722 to 2,524.

At equal intervals during these trials, diagrams were taken with an ordinary indicator. The working-out of these diagrams gives a power, in the case of spirit, of 11,975 foot-pounds per minute, and, in the case of water, of 5,199 foot-pounds per minute, which more than confirms the results obtained by the brake.

Touching the class of spirit used for the experiments, Mr. Yarrow mentioned that it was a hydrocarbon distilled from petroleum, having a specific gravity of about .680. The reason this spirit was adopted was because it is low in price, and can be easily procured; and also, being obtained from petroleum, it is of an oily nature. A spirit which is not oily in its character would be deficient in lubricating-power, and therefore not so suitable for working the machinery.

Touching the evaporation of spirit to produce power in actual practice, at present the only application which has been successfully developed is for the propulsion of launches. It is termed the "Zephyr" system. For small sizes, certainly there would seem to be no question, that, where the spirit is obtainable, this system is destined to take the place of steam, not so much on account of the probable increased efficiency, as the general convenience of the arrangement. A launch propelled on this plan, 36 feet long by 6 feet beam, and built of steel, has a total weight, including machinery, of only one ton; while, had it been propelled by steam, the weight would have been considerably greater.

Mr. Yarrow did not venture to assign any reason for the apparent gain in the use of spirit over water, but pointed out, that, in a condensing-engine, the two great losses of heat are due, first, to the waste gases which pass up the funnel, and simply go to raise the temperature of the surrounding air; and, second, to the loss arising through raising the temperature of the condensing-water, which goes to warm the sea.

As regards the first loss, it is self-evident, that, owing to the low temperature at which the spirit evaporates, the products of combustion are available to produce evaporation down to a much lower temperature than in the case of water. As an illustration of the low temperature at which the waste gases pass away in the "Zephyr" launches, when going at full speed, it is quite possible to hold one's hand immediately over the funnel.

The results of these experiments give reasonable ground for believing that this system, in some form, is capable of further and possibly extensive development.

WEST INDIAN HURRICANES.

JUNE is the first of the five months that constitute the hurricane season, and every navigator bound for the tropics should now be on his guard, and watch for the earliest indications of an approaching cyclone, lest it may be of hurricane violence. The "Pilot Chart" last month contained a small chart illustrating the general tracks along which these storms move, together with a diagram explaining the importance of the fact that the tracks recurve in a latitude dependent upon the month. In June, for instance, the point of recurvature is in about latitude 20° to 23° north, and here the entire storm moves in a northerly direction, while in lower latitudes it moves north-westerly, and in higher latitudes north-easterly. Each of the accompanying diagrams is therefore applicable to a slightly different belt of latitude, according to the month, as stated therewith. There may be an occasional exception, but a navigator can at first only be guided by the general rule.

A careful study of these diagrams will, it is thought, enable a navigator to form a clear idea as to the general character of West Indian hurricanes. It should, of course, be understood that no two hurricanes are exactly alike; and a master of a vessel can only be guided by what is known from the experience of others, his own experience, and the indications that he can obtain from the weather, wind, barometer, cloud-movements, etc. It is now generally recognized that the old 8-point rule is not always a safe guide for action; and, although the storm-card based upon it has been published on the "Pilot Chart" up to the present time, efforts have been made to explain the spirally inblowing character of the winds in a cyclone. The old storm-card and the 8-point rule can no longer be recommended, except, perhaps, as a rough-and-ready rule for those who will not take advantage of the progress that has been made since this old rule was established. By looking at any one of these diagrams, for instance, it will be seen that the bearing of the centre is hardly ever exactly eight points to the right of the wind, but is generally considerably more than that, especially in rear of the storm. It will be noticed, also, that the storm is never exactly circular, and that its shape changes as it moves along its track. The limited space on the chart forbids any detailed discussion of the subject; but the following brief *résumé*, prepared for the information and guidance of practical navigators during the present hurricane season, is taken from the June "Pilot Chart:"—

The hurricane regions embrace the tropics north of the 10th parallel, the Caribbean Sea, Gulf of Mexico, and a broad belt curving north-westward from about St. Thomas, and following the Gulf Stream toward the Grand Banks of Newfoundland.

The earliest indications are, unusually high barometer, with cool, dry, fresh winds, and very transparent atmosphere; a long, low ocean-swell from the direction of the distant storm; light, feathery plumes of cirrus clouds, radiating from a point on the horizon where a whitish arc indicates the bearing of the centre.

Unmistakable signs of a hurricane are the following: As the cirrus veil spreads overhead, with halos about the sun and moon, the barometer begins to fall, slowly but steadily, and the ocean-swell increases; the air becomes heavy, hot, and moist; dark red and violet tints are seen at dawn and twilight; the heavy cloud-bank of the hurricane soon appears on the horizon, like a distant mountain range; the barometer falls more rapidly, and the wind freshens, with occasional squalls of fine, misty rain.

As to general size and velocity of progression, the storm area is smaller in the tropics than farther north, the cloud-ring averaging about 500 miles in diameter, and the region of stormy winds 300 miles or even less. In low latitudes the entire storm moves westward and north-westward about 17 miles an hour; in middle latitudes, north-westward and northward, moving more slowly as it recurves; and finally north-eastward, with a velocity of translation of 20 or even 30 miles an hour, its area increasing rapidly as it follows the Gulf Stream toward the Grand Banks, and sweeps across the Atlantic toward northern Europe.

One of the most important indications that an approaching storm is of hurricane violence is the marked cyclonic circulation of the wind, lower and upper clouds, etc. This may be easily appreciated by remembering that a cyclone of any great intensity is an ascending spiral whirl, with a rotary motion (in the northern hemisphere) against the hands of a watch, as shown on the diagrams. The surface wind, therefore, blows spirally inward (*not* circularly, except very near the centre); the next upper current (carrying the low scud and rain clouds), in almost an exact circle about the centre; the next higher current (the high cumulus), in an outward spiral; and so on, up to the highest cirrus clouds, which radiate directly outward. The angle of divergence between the successive currents is almost exactly two points of the compass. Ordinarily, with a surface wind from the north, for instance, the low clouds come from the north also; on the edge of a hurricane, however, they come from north-north-east invariably. In rear of a hurricane, the wind blows still more nearly inward. With a south-east wind, for instance, the centre will bear about west, the low clouds coming from south-south-east (two points to the right of the wind), etc. Great activity of movement of the upper clouds, while the storm is still distant, indicates that the hurricane is of great violence.